Vacuum Brake Booster

DESCRIPTION

[Para 1] This invention relates to a control valve having first and second cylindrical members that travel at different rates during a brake application such that the travel of the input member is less than travel of the output member.

BACKGROUND OF THE INVENTION

[Para 2] In the development of brake boosters it became evident that by dividing the interior cavity of a housing by two diaphragm members a resultant output force could be significantly increased. In some of the resulting tandem brake boosters such as disclosed 5,233,911 communication between the chambers is achieved through passages in a hub that retains a control valve that is responsive to an operator input for the development of a pressure differential across the diaphragms that separate a rear chambers from a front chambers while in other tandem brake boosters such as disclosed in U.S. Patents 3,083,698; 3,517,588 and 3,760,693 the rear chambers are connected to each other through flow path created between a peripheral surface of a partition member and housing. A partition member that is usually made of a plastic material engages the hub to separates a front chamber from an adjacent rear chamber. In some of such boosters, the partition member may move or float within the interior cavity as a function of a pressure differential developed during a brake application. In any event, the hub moves from a position of rest within the housing to an actuation position that is in a direct relationship to the movement of the plunger by the input force. Thus, when an operator applies an input force on the brake pedal, the arcuate travel of the brake pedal is translated into linear movement of the plunger. Unfortunately a desired brake force may not always be achieved if a total linear travel of the

plunger occurs prior to the ultimate arcute travel of the brake pedal as manual input is not added to the output force when a maximum boost assist is reached.

SUMMARY OF THE INVENTION

[Para 3] An advantage of the present invention resides a brake booster having a control valve arrangement wherein the travel of a plunger in response to an input force from an input member in the development of an output force is about one-half the travel of an output member for pressurizing fluid in a master cylinder to effect a brake application.

[Para 4] According to this invention, a hub for a wall arrangement that separate the interior of the housing of a brake booster into first and second chambers is defined by concentric first and second cylindrical members. The first cylindrical member has a first stepped bore therein that receives the second cylindrical member while the second cylindrical member has a second stepped bore for receiving a plunger that is connected to a brake pedal. The first cylindrical member has first and second longitudinal slots adjacent the first stepped bore that extend from a first end toward a second end and passages therein that connect the first and second chambers. The second cylindrical member has third and fourth longitudinal slots that extend from the second cylindrical bore and first and second openings that are normal to the third and fourth longitudinal slots. A gear has an axle that is fixed in the first and second openings in the second cylindrical member with a first plurality of teeth that extend through the third longitudinal slot and engage a first rack retained in the first longitudinal slot in the first cylindrical member and a second plurality of teeth that extend through the fourth longitudinal slot and engage a second rack that is located within the second longitudinal slot and fixed to the housing for the brake booster. The plunger has a fifth longitudinal slot that is located between a first end thereof and second end thereof with first and second longitudinal oval openings normal to the fifth

longitudinal slot. The axle of the gear extends through the oval openings such that plunger may independently move within the second stepped bore without movement of either the first or second cylindrical members. An input force applied to the input member moves the plunger to allow a pressure differential to be established across the wall arrangement and develop an output force that moves the wall arrangement and first cylindrical member. The output force is directly applied from the first cylindrical member to a first piston that is located in a bore of a master cylinder to pressurize fluid therein and creating operational pressurizing fluid that is supplied to the wheel brakes of a vehicle to effect a brake application. The first piston has a bore therein that retains a second piston connected through a reaction disc located in the second stepped bore adjacent an end of the plunger. The operational pressurized fluid acts on the second piston to oppose the input force and when in balance with the input force terminates the communication of air to the rear chambers in the development of the pressure differential. When the first cylindrical member moves the first rack transmits a torque through the first rack into the first plurality of teeth such that the gear rotates and moves the second plurality of teeth on the second rack such that the second cylindrical body to moves away or in an opposite direction with respect to the first cylindrical member and as a result the travel of input member is less than the travel of the wall during the brake application.

[Para 5] An advantage of this invention resides in a control valve arrangement wherein an output force produced in response to a pressure differential developed across a wall is proportional to an input force and yet the travel associated with an output member is less than the travel of an input member.

[Para 6] A further advantage of this invention resides in an ability to select a travel relationship between an input member and an output member as a function of a pitch between a gear and a rack arrangement.

BRIEF DESCRIPTION OF THE DRAWINGS

[Para 7] Figure 1 is a sectional view a brake booster for a brake system having a valve arrangement assembly made according to the principals of the present invention;

[Para 8] Figure 2 is an enlarged sectional view of the valve arrangement of Figure 1;

[Para 9] Figure 3 is a top view of an internal cylindrical member that retains a plunger for the control valve of Figure 1;

[Para 10] Figure 4 is an end view of the cylindrical member and plunger of Figure 3;

[Para 11] Figure 5 is a sectional view taken along line 5-5 of Figure 4;

[Para 12] Figure 6 is a top view of a plunger that is retained in the cylindrical member of Figure 3;

[Para 13] Figure 7 is a side view of the plunger of Figure 6;

[Para 14] Figure 8 is a sectional view taken along lines 8-8 of Figure 1;

[Para 15] Figure 9 is a sectional view taken along lines 9-9 of Figure 4;

[Para 16] Figure 10 is a sectional view taken along lines 10-10 of Figure 9;

[Para 17] Figure 11 is a sectional view of the brake booster of Figure 1 showing the relationship of the components of the control valve arrangement at the initiation of a brake application;

[Para 18] Figure 12 is a sectional view of the brake booster of Figure 1 showing the relationship of the components of the control valve arrangement during a brake application; and

[Para 19] Figure 13 is a sectional view of the brake booster of Figure 1 showing the relationship of the components of the control valve arrangement during a manual brake application.

Detailed Description of the Invention

[Para 20] The brake booster 10 shown in Figure 1 is made according to the present invention and is distinguished in that linear travel of an input member 12 in response to an input force applied to brake pedal 14 is less than and preferably about one half of the travel of an output member 16 in applying an operational force to pistons 19(only one is shown) in a bore 18 of master cylinder 20 to develop operational pressurized fluid that is supplied to a plurality of wheel brakes 22,22'...22^n to effect a desired brake application.

[Para 21] The brake booster 10 has a housing produced by fixing a front shell 24 to a rear shell 26 by rolling a lip 28 on the rear shell 26 over an annular flange 30 on the front shell 24 to create a unitary structure of a type illustrated in U.S. Patent 6,390,567. In fixing the front shell 24 to the rear shell 26 an interior cavity is created and separated into a first chamber 34 and a second chamber 36 by a first diaphragm assembly 38 and into a third chamber 40 and a fourth chamber 42 by a second diaphragm assembly 44. The second chamber 36 is separated from the third chamber 40 by a partition member 46 that has a peripheral surface that engages the rear shell 26 and an inner surface that sealingly contacts a peripheral surface 104 on a first cylindrical member 160 of a hub arrangement 60.

[Para 22] The first diaphragm assembly 38 includes a resilient member 41 that has a first bead that is sealingly secured to the partition member 46 and a second bead that holds a backing plate 39 against a first shoulder 161 on the first cylindrical member 160, see Figure 2. The second diaphragm assembly 44 is similar to the first diaphragm assembly 38 in that a resilient member 43 has a first bead sealingly secured between the front shell 24 and rear shell 26 and a second bead that holds a backing plate 45 against a second shoulder 163 on the first cylindrical member 160. The first chamber 34 is

permanently connected to the third chamber 40 by a first passage 162,162' in the first cylindrical member 160 while the second chamber 36 is permanently connected to the fourth chamber 42 by a passage 164,164' in the first cylindrical member 160, see Figure 8. The first cylindrical member 160 has a stepped bore 166 therein that extends from a first end 168 to a second end 170 and is designed to receive a second cylindrical member 200. The second cylindrical member 200 has an axial bore 202 therein and a plurality of passages 204, 204'...204^n that extends from a first end 205 to a vacuum seat 206 that is located a distance from a second end 208, see Figures 3,5,8,9 and 10. A tubular arrangement 300 that includes a plurality of tubes 302,302'...302^n each have an annular flange 304 that is retained in a seat 172 in openings in annular rib 174 on the second end 170 of the first cylindrical member 160. The plurality of tubes 302,302'...302^n sealingly extends into the plurality of passages 204,204'...204^n such that the first chamber 34 is in constant communication to the vacuum seat 206 and as a result the first chamber 34 may be selectively connected to the fourth chamber 42 and ultimately to the second chamber 36 through passage 164 in response to actuation of control valve 48 that is located in axial bore 202.

[Para 23] The control valve 48, see Figure 2, includes a poppet member 52 and a plunger 54 that is connected to push rod 12 to receive an input force from brake pedal 14. The plunger 54 being retained in bore 202 by a key 91 while the poppet member 52 has a first end that is fixed to the second cylindrical member 200 and a flexible annular face 56 that is urged toward vacuum seat 206 by a first spring 47 while a second spring 45 acts on the push rod 12 to urge the plunger 54 toward an atmospheric seat 51 on face 56 of the poppet member 52.

[Para 24] In response to an input force applied by an operator to brake pedal 14, push rod 12 moves such that spring 47 urges face 56 into engagement with vacuum seat 206 on the second cylindrical member 200 to interrupt normally opened communication of fluid in the first chamber 34 through the passages 204,204'...204^n and thereafter moves plunger 54 away from atmospheric seat 51 to allow air from the surrounding environment to be

communicated to the rear or second 36 and fourth 42 chambers by way of stepped bore 202 and passage 164,164'. Air supplied to chambers 36 and 42 creates a pressure differential with vacuum permanently available in chambers 34 and 40 such that an output force is created across the first 38 and second 44 diaphragm assemblies. This output force is carried through the first 38 and second 44 diaphragm assemblies into the first cylindrical member 160 and after overcoming return spring 63 directly provides output member 16 with an operational force that moves pistons 19 and pressurizes fluid in bore 18 of the master cylinder 20 to an operational fluid pressure commensurate with the input force applied to brake pedal 14 to effect a brake application in wheel brakes 22,22'...22^{n}. The travel of push rod (input member) 12 in positioning the control valve 48 to develop the operational force to move push rod (output member) 16 and pressurize fluid in the master cylinder is less than and preferably about one half the travel of push rod (output member) 16 in effecting the brake application.

[Para 25] In more particular detail, the first cylindrical member 160 and second cylindrical member 200 define a hub for the first 38 and second 44 diaphragm assemblies and are distinguished in that the first cylindrical member 160 moves at a different rate of travel during a brake application than the second cylindrical member 200 with the rate being established as a function of a relationship between first 400 and second 402 racks that are retained in the first cylindrical member 160 and a gear 500 that is fixed to the second cylindrical member 200.

[Para 26] The first cylindrical member 160 has a peripheral surface 104 with a uniform diameter that extends from the first end 168 to a shoulder 108 adjacent a second end 170 that is engaged by seal 49 on partition member 46, as shown in Figure 2. A bead on diaphragm 41 and a surface of backing plate 39 of the first diaphragm assembly 38 are retained in a groove 110 on the first cylindrical member 160 while a bead on diaphragm 43 and a surface of backing plate 45 are retained in a groove 112 of the first cylindrical member 160. A stepped bore 166 extends from the first end 168 to the second end 170 while first 114 and second 116 longitudinal slots radiate from the first

stepped bore 166 and extend from the first end 168 toward the second end 170, see Figures 2 and 8. As best shown in Figure 8, the first 114 and second 116 longitudinal slots may also have first 115,115' and second 117,117' longitudinal slots for connecting the first end 168 and chamber 42 with chamber 36 by way of a radial opening 39 that is located adjacent shoulder 108 on the second end 170.

[Para 27] The first slot 114 in cylindrical member 160 receives a first rack 400 that is free to move therein but is restricted from moving past end 168 by a clip or tab 176 that is fixed to the first cylindrical member 160 by a screw 176a. The second slot 116 also receives a second rack 402 that has a first end with an annular flange 404 that is fixed to the rear shell 26 by screws 27,27'. Thus, the first rack 400 is free to move within the first slot 114 while the second rack 402 is fixed and stationary within the cavity.

[Para 28] The second cylindrical member 200 is further defined by essentially a uniform diameter on a peripheral surface that extends from a first end 205 to a second end 208, this peripheral surface is concentric to diameter 166 on cylindrical member 160 such that the second cylindrical member 200 may move freely move within diameter 166, see Figures 2,3,4,5,8,9 and 10. The stepped bore 202 is located on the axis of the second cylindrical member 200 and extends between the first 205 and second 208 ends has third 210 and fourth 212 longitudinal slots that extend from the second stepped bore 202. The third 210 and fourth 212 longitudinal slots are located in a same radial plane and are located near the first end 205 and between a key slot 214 and the second end 208. The cylindrical member 200 has first 216 and second 218 lateral openings therein with respect to the axis of the second cylindrical member 200 that are normal to third 210 and fourth 212 longitudinal slots. An internal annular rib 220 adjacent the first end 205 defines a face for receiving a resilient or reaction disc 70 that is retained in a head 72 on a shaft 274 that is located within an axial bore 71 of shaft 75 of the output member 16.

[Para 29] Plunger 54 of the control valve 48 that is located in axial bore 202 of the second cylindrical member 200 and as best illustrated in Figures 2, 5,6 and 7 is further defined by a shaft extension 80 that is located in diameter 202a of the second stepped bore 202. The end 82 of shaft extension 80 is positioned adjacent the first end 205 of the second cylindrical member 200 and designed to engage reaction disc 70. As illustrated in Figure 6, shaft extension 80 has a fifth longitudinal slot 84 therein, see Figures 5 and 7, with first 86 and second 88 lateral oval openings that extend from and are normal to the fifth longitudinal slot 84 and a shoulder 85. The fifth longitudinal slot 84 receives a gear 500 that connects the first rack 400 to the second rack 402.

[Para 30] Gear 500 has an axle 501 that is aligned with the first 216 and second 218 lateral openings in the second cylindrical member 200 and with the first 86 and second 88 oval openings in shaft extension 80 of plunger 54. A pin 90 passes through first 86 and second 88 oval openings and is retained in the axle 501 and first 216 and second 218 lateral openings in the second cylindrical member 200 such that teeth 502 on a peripheral surface of gear 500 extend through the third 210 and fourth 212 longitudinal slots and into the first 114 and second 116 longitudinal slots. A first plurality of teeth 502 on gear 500 engage teeth 408 on the first rack 400 located in the first longitudinal slot 114 while a second plurality of teeth 504 on gear 500 engage teeth 410 on the second rack 402 located in the second longitudinal slot 116. The sides of the gear 500 engaging the side of the first 114 and second 116 slots such that gear 500 is aligned in a vertical plane along the axis of the input member or push rod 12 that is axially aligned with the output member 16.

[Para 31] The output member 16 is distinguished in that shaft 75 that extends from piston 19 engages rib 174 on the first cylindrical member 160 and moves the piston 19 at a same rate of travel as the first cylindrical member 160 to communicate an output force for pressurizing fluid in bore 18 of the master cylinder 20 to effect a brake application. The piston 19 has a passage 19a through which the fluid in bore 18 is communicated to a reaction

chamber 275 formed in bore 71 through the engagement of shaft 274 with shaft 75.

Operation of the Brake Booster

[Para 32] When an operator desires to effect a brake application for a vehicle equipped with brake booster 10 an input force is applied to brake pedal 14 that moves push rod 12 such that spring 47 urges face 56 into engagement with vacuum seat 206 on the second cylindrical member 200 to interrupt normally opened communication of fluid in the first chamber 34 through the passages 204,204'...204^n and thereafter moves plunger 54 away from atmospheric seat 51 to allow air from the surrounding environment to be communicated to the rear or second 36 and fourth 42 chambers by way of stepped bore 202 and passages 164,164'. Initially shaft extension 80 moves with respect to pin 90 as the oval slots 86,88 have a length that allows closure of the vacuum seat 206 and the opening of the atmospheric seat 51 before movement of either the first cylindrical member 160 or second cylindrical member 200. With air being supplied to chambers 36 and 42 and a pressure differential is created across the walls, defined by the first 38 and second 44 diaphragm assemblies, with vacuum permanently available in chambers 34 and 40 to create an output force. The output force is carried through the first 38 and second 44 diaphragm into the first cylindrical member 160 and after overcoming return spring 63, the first cylindrical member 160 and piston 19 move at a same rate of travel to pressurize fluid in bore 18 of the master cylinder 200 and create an operational fluid pressure commensurate with the input force applied to brake pedal 14 to effect a brake application in wheel brakes 22,22'...22^n. When the first cylindrical member 160 begins to move, the end of rack 400 engages clip or tab 176 and teeth 408 on the first rack 400 engage teeth 502 on gear 500 to impart a rotative torque to gear 500 that causes teeth 504 to move on teeth 410 of the second rack 402. With the axle 501 of gear 500 fixed to the second cylindrical member 200 movement or travel of the axle 501 and also the second cylindrical member 200 is a function

of a ratio of the radius of the gear 500 divided by the diameter or one half the travel of the first cylindrical member 160, in any event the travel of the first cylindrical member 160 and the second cylindrical member 200 are different. Preferably the travel of the input member or push rod 12 is about one half the travel of the out put member or push rod 16 such that now a force required to pressurize fluid in a master cylinder is not limited by the travel of the brake pedal 14 in moving the input rod 12. Functionally, whenever piston 19 moves in bore 18 operational pressurized fluid is produced and in addition to being supplied to the wheel brakes is also communicated to the reaction chamber 275 to act on shaft 274. The operational pressurized fluid acting on shaft 274 provides a reaction force that acts on reaction disc 70 to press against face 81 of shaft extension 80 and oppose the input force applied to plunger 54 such that the resulting output force is matched with the input force in effecting a brake application. When the input force is removed from the input member 12, return spring 63 acts on the first cylindrical member 160 to return the first 38 and second 44 diaphragm assemblies to the position of rest shown in Figure 1 and 2.

[Para 33] During a brake application should a maximum pressure differential be utilized, a manual input applied to the input member 12 may further act on plunger 54 to move plunger extension 80 within bore 202a such that end 82 engages reaction disc 70 and moves shaft 274 within bore 71 to pressurize fluid in reaction chamber 275 to provide additional pressurization of the operational fluid supplied to the wheel brakes 22,22'...22^{n}.

[Para 34] In an event where vacuum may not be available or present in the first 34 and third 40 chambers, a manual application may be achieved through the application of an input force applied to the brake pedal 14. In this situation, plunger 54 moves in axial bore 202 as before but without vacuum present in the first 34 and third 40 chambers a pressure differential is not created across the first 38 and second 44 diaphragm assemblies and as a result the first cylindrical member 160 does not independently move. However, when plunger 54 and shaft extension 80 have moves a distance equal to the length of oval slots 86 and 88, shoulders 85,85' engage the

second cylindrical member 200 and provide a force that causes gear 500 to rotate as teeth 504 move on teeth 410 on the second rack 402 while teeth 502 engage teeth on teeth 408 on the first rack 400 and move then in linear slot 114 to a position as illustrated in Figure 13 such that an input force is transmitted into the

[Para 35] output member 16 to effect a brake application.